

National Aeronautics Space Administration



NASA Safety Center

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Using Case Studies To Assure **MISSION SUCCESS**

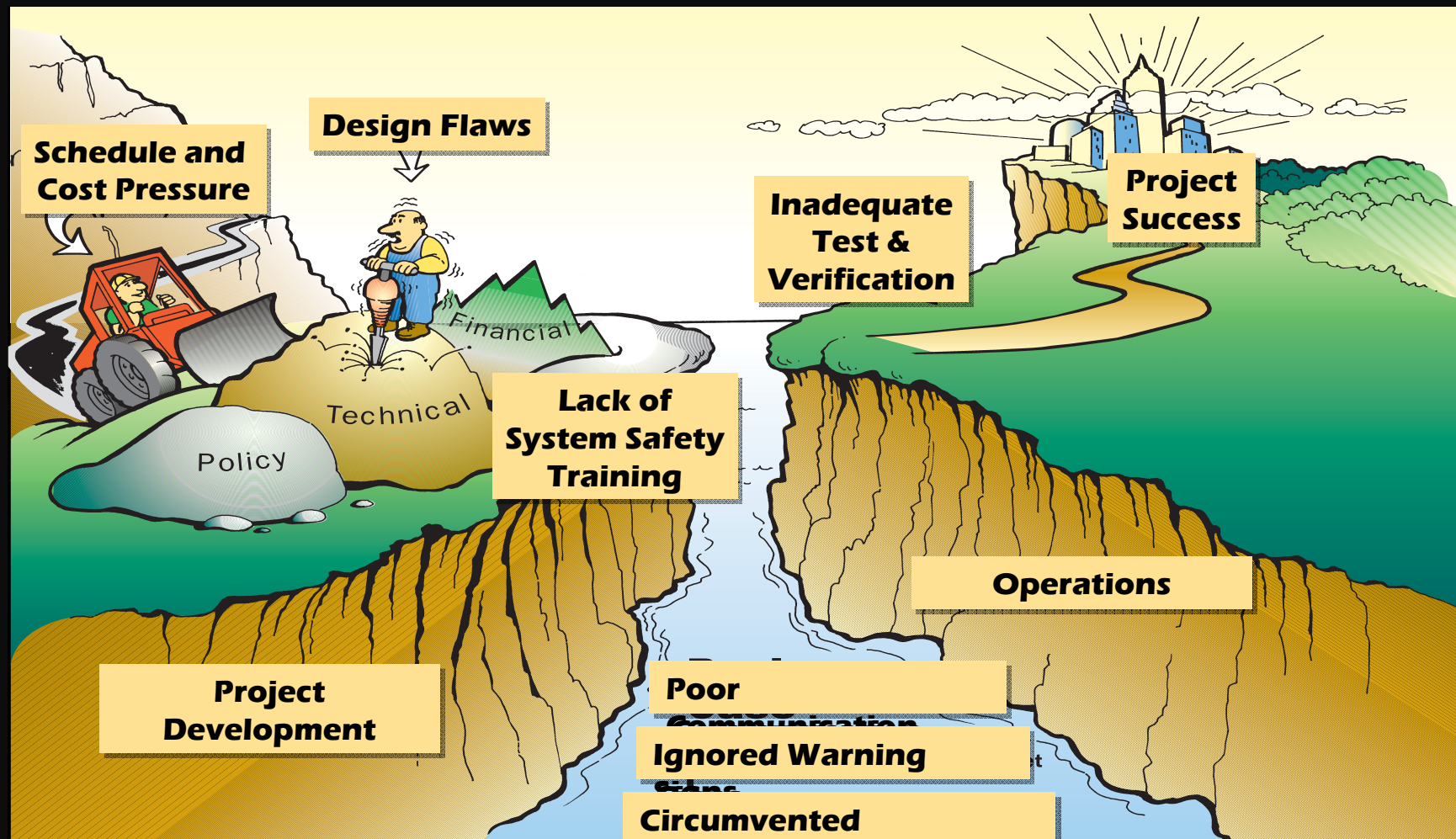


Purpose of This Session

Introduce you to...

- ▶ The value of case study based discussion within your project teams
- ▶ How these case studies can be used to create well integrated and effective project teams
- ▶ Two different types of case studies that you can easily access via web
- ▶ Structured training and seminars that you can schedule for your program

Projects Can Be A Treacherous Journey



Why Case Studies Are So Effective

- ▶ They use a storytelling approach to describe interesting events or mishaps
- ▶ They engage the reader into the thought processes and emotions of those that lived the experience
- ▶ They enlighten us to the ways in which scenarios could unfold, and what we can each do to disrupt an undesired outcome

An Intro To Two Types Of Case Studies



- ▶ **System Failure Case Studies** - focusing on larger scale more complex and “highly visible” events which have occurred both inside and outside of NASA



- ▶ **Cases of Interest** - focusing on cases which have high risk/mishap potential

System Failure Case Studies (SFCS)

Common Mishap Themes

- ▶ A study of 13 case studies identified common mishap themes

Lack of System Safety Awareness or Training	Engineering Design Flaws	Improper or Circumvented Procedures (Configuration Management)	Inadequate Verification and Testing	Ignored "Warning Signs"	Poor Communication	Schedule and/or Cost Pressures	Human Interaction with System	Ineffective Program/Project Management	Automated System Failure	Developing New Technologies
2006										
Death on the Steppes	X	X	X		X		X	X	X	X
Submarine Down	X	X		X			X			
2007										
Almost Perfect	X	X	X			X		X	X	
Derailed	X	X	X	X	X		X			
Innovations Pushed Too Far Too Fast	X	X		X	X	X	X			X
Lewis Spins Out of Control	X	X	X	X	X	X	X	X	X	
Rocky Mountain Death Trap	X	X	X	X			X	X		
Supercritical	X	X	X	X	X		X	X		X
2008										
Fire in the Cockpit	X	X		X	X		X			
Forrestal in Flames	X	X	X	X	X	X	X	X	X	
Powerless	X	X	X	X		X			X	
Refinery Ablaze - 15 Dead	X	X	X		X		X	X	X	
Two Rods Don't Make It Right	X	X	X		X	X	X	X		

System Failure Case Studies (SFCS)

THAT SINKING FEELING

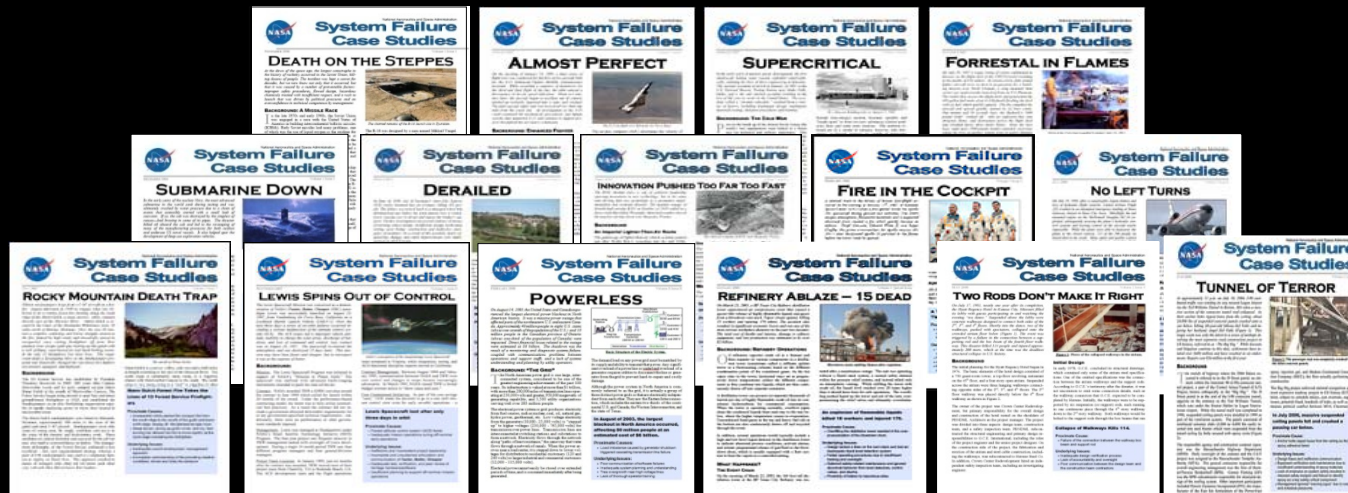


“The project successfully rejected ... prescriptive engineering, onerous quality requirements, and outdated concepts of inspection ...”

A Petrobras executive after delivering superior financials

SFCS History

- ▶ System Failure Case Studies (SFCS)
- ▶ Began in 2006
- ▶ Produced monthly
- ▶ Mix of NASA and non-NASA case studies
- ▶ 4 page write-up complimented by PowerPoint brief with highlights
- ▶ Key Points
 - ▶ Background and overview of failure
 - ▶ Proximate and underlying causes
 - ▶ Applicability to NASA



SFCS – Where To Find

Internal to NASA
<http://nsc.nasa.gov>
 or
 External to NASA
<http://pbma.nasa.gov>

SFCS Archive

Title	VITS	SFCS	Video
Powerless - Northeast Blackout of 2003			
Fire in the Cockpit - The Apollo 1 Tragedy			
Forrestal In Flames - US Aircraft Carrier Forrestal			
Lewis Spins Out of Control - Lewis Space Craft			
Supercritical - SL-1 Nuclear Reactor			
Almost Perfect - X31 (Videos are NASA Only)			
Rocky Mountain Death Trap: The Mann Gulch Fire - Team Dynamics			
Innovation Pushed Too Far Too Fast - R-101 Dirigible			
Derailed - The Eschede Train Disaster			
Close Call - Location: VAB, KSC - Harness Safety			
Atlas Centaur (AC-67) Lightning Strike Mishap 1987			
Radiation Cancer Therapy Machine Mishaps in 1985-86 due to Safety Critical Software Control Errors - Radiation Therapy Overdose			
Mishap at an Explosives R&D Laboratory - ATK Thiokol Explosives Lab			
Ames Arc Jet DC Power Supply Fire			
The Davis-Besse Close Call - Davis-Besse Nuclear Reactor			
Air Force Atlas Mishap Due to Unintended Mixing of LOX and Hydrocarbons 1975 - Air Force Atlas 71F			
SUBSAFE - USS Thresher, SSN 593, Lesson Learned			
Are We Prepared for the Upcoming Hurricane Season?			
A Gift - STS-3			
Fatal Mishap Resulting from a Pressure System Operation in Government Laboratory			
Chemical Safety Board's (CSB) Findings in New York Chemical Waste-Mixing Incident - Kaltech Chemical			
And some have said "software isn't critical" - Ariane 5			
Chemical Safety Board's Preliminary Findings in BP Texas City Refinery Accident			
A Tale of Two Failures... the difference between a "Bad Day" and a "Nightmare" - Delta II 7925/Long March CZ-3B			
Death on the Steppes - The Nedelin Rocket Disaster			
Failures, Mishaps and Root Cause Analysis - Hurricane Katrina			
Steam Locomotive Firebox Explosion on the Gettysburg Railroad near Gardners, Pennsylvania			
Equilon Refinery Accident Anacortes, WA			
Bhopal: When Hazard Controls Aren't			
MGM Grand Hotel Fire Disaster, A Turning Point for Fire Protection Codes			

SFCS - Structured Training and Seminars

Training	Objectives	Forum	Time
Familiarization Brief	- Introduce SFCS's	Auditorium or seminar	20-30 minutes
Issue Brief	- Focus on specific issue	Auditorium or seminar	20-30 minutes
Case Study Analysis	- Lessons learned - Increase awareness of current risks	Seminar/ Focused Group	1 hour to 1+30
Knowledge Café (3 Case Studies)	- Wide Breadth of lessons learned - Increase awareness of current risks	Seminar/ Focused Group	3 Hours
Decision Making Seminar (1 Pre-failure Case Study)	- In depth lessons learned - Increase awareness of current risks - Emphasis on risk identification and mitigation	Seminar/ Focused Group	4 Hours

Cases of Interest (Col)

NPR 7150.5D para 6.2.1g:

“Assure that the project team seeks to learn and apply relevant lessons from successful flight systems and ground support projects, *mission anomalies and mishaps.*”

Why Cases of Interest?

Knowledge Capture and Dissemination to:

- *Ensure that we're informed risk takers*
- *Manage the routine risks in the workplace effectively*
- *Preserve our resources for the execution of the NASA Mission.*

- ▶ Given the current breadth of information contained in events that are not high visibility....

- ▶ How do we “tap” into these events and experiences

- ▶ For audit planning?
- ▶ For training/technical excellence?
- ▶ For awareness? For targeted audiences?

- ▶ *For Mishap prevention and Mission Success?*

Type A's and B's-138

Type C's - 6,529

Type D's - 8,467

Type Close Calls - 23,164

*Data collected in IRIS between 1984 to 2007

What was needed was an approach to...

- ▶ Analyze the bulk of data utilizing filters to identify precursors and hazards
- ▶ Identify a case for storytelling and distribution that will emphasize the precursors and hazards
- ▶ Include suggestions for prevention, training, auditing
- ▶ “Brand” this information obtained from the analysis so it is recognizable and meets expected knowledge management needs



COI Prevention Marker analysis

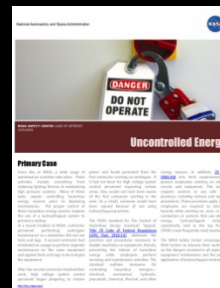
- ▶ Could there have been a potentially catastrophic event associated with the IRIS case?
- ▶ Are broad effects likely?
- ▶ Are there serious consequences/effects across system boundaries? (coupled, uncoupled systems and or complex systems)
- ▶ Special Case-Is there a control failure?
- ▶ Are there hazardous latent conditions?
- ▶ Is there extensive incident documentation in the IRIS case file?
- ▶ Is there extensive corrective action documentation in the IRIS case file?
- ▶ Is there a time critical hazard or “top level risk” that needs to be addressed?

COI knowledge sharing product

- ▶ Selection considerations for the desired message
 - ▶ Agency goals
 - ▶ Trends for safety awareness
 - ▶ Applicability to general operations
 - ▶ Timeliness of information
 - ▶ Relevance to developing programs
 - ▶ Relevance to recent mishaps
 - ▶ Recent audit findings
 - ▶ Applicability to current agency business processes


COI History

- ▶ Cases of Interest “concept of operations”
- ▶ Began in 2006
- ▶ Produced monthly from the prevention marker analysis of mishaps, close calls and hazards reported into the *Incident Reporting Information System (IRIS)*
- ▶ Representing cases which typifies a specific mishap trend or have broad based applicability to both ground and flight operations
- ▶ 2 - 4 page write-up complimented by web site with links to related information such as similar incidents, related requirements, best practices, highlights from the event, applicable training, and suggested auditing and quality control
- ▶ Key Points
 - ▶ Background and overview of failure
 - ▶ Compliance information, related documentation and other background data that can assist members of the NASA Community in mitigating the hazards associated with the CoI event.
 - ▶ Applicability to NASA operations



Sample COI Knowledge Sharing Product

National Aeronautics and Space Administration



NASA SAFETY CENTER CASE OF INTEREST
3/24/2008

Hotter Than the Sun Arc Flash Safety

Primary Case

Imagine one second you are working on high-voltage switch gear going about your routine maintenance activities, and the next second you are caught in an explosion that hits you so hard it throws you to the ground. This massive energy discharge burns the bus bars, vaporizing the copper at temperatures up to 35,000 F. Liquid metal sprays you at hundreds of miles per hour. Deadly shrapnel created by the explosion tears into your body. You have just experienced an ARC FLASH. The damage is severe, sometimes fatal, and rarely anticipated.

Arc flash injuries are caused by the explosive expansion of hot gases as electricity arcs between two points of differing voltage potential. The blast may knock an individual down and may cause acoustic damage to the ears. Skin burns and debris damage to eyes may occur if protective equipment is not worn. Arc flash burns are thermal burns and require management according to the burn degree and surface area involved. If there is any concern the burn could be electrical, not thermal, the individual should not delay transportation to a medical facility.

NASA uses a wide variety of high-voltage equipment in the execution of its mission. Utilizing the proper procedures and techniques in the maintenance of this equipment is essential to the safety of electrical maintenance personnel and continuity of NASA operations.

A NASA contractor recently received second degree thermal burns to both hands due to an arc flash that occurred when the worker replaced a metal cover on a 277/480 volt kilowatt hour meter box. The worker was transported to the on-site clinic by a co-worker, treated and subsequently transported to hospital for further treatment. A Mishap Investigation Board (MIB) has been established and is currently investigating the cause. The NASA Safety Center Investigation Support Office (ISOI) issued advisories based on this incident. Please contact [Israel Green](mailto:Israel.Green@nasa.gov) for additional information regarding advisories.

In addition to focusing on the safety of the arc flash hazard, the NASA Safety Center encourages all field Centers to educate their workforce on the safety of electrical maintenance personnel and continuity of NASA operations.

* **High Voltage Switchgear:** located in a Substation at NASA's Glenn Research Center in Cleveland

<http://hsc.nasa.gov/>

National Aeronautics and Space Administration



NASA SAFETY CENTER CASE OF INTEREST
3/24/2008

Ghost in the Machine RF-Controlled Crane Safety

Primary Case

NASA operates cranes and lifting devices of every kind in the execution of its mission. The proper operation of cranes and lifting devices is critical to the safety of personnel and the prevention of equipment damage.

Apart from the typical hazards associated with the use of cranes and lifting devices (e.g. properly secured loads, worn rigging equipment), hazards that are not so obvious can also be present. In May 2007, a crane at a NASA Center that is controlled using Radio Frequencies (RF) began lifting an object without the key being on or the operator actuating the controls of the crane. This was a close call that could easily have resulted in equipment damage or severe injury.

In this incident, RF emissions from another crane caused the uncommanded movement. It is important to recognize that any emitter of the same frequency and sufficient power within range of the affected crane would have posed similar risk.

As a result of this incident, a program was put in place to insure the operating frequencies of all radio controlled cranes have sufficient frequency separation to avoid "Cross Talk" between cranes so that similar incidents are precluded. As part of this program, a list will be maintained of all crane control radio frequencies used and this information will be shared with interested parties. Whenever periodic surveys of this type identify emitters that can interfere with equipment operation or cause hazardous personnel exposure, engineering alternatives such as shielding, alternate frequencies, or reduced power output would be the first choices in a hazard control scheme. If these engineering alternatives are not feasible, an effective administrative control option is a plan of operation that allows emitter use while mitigating hazardous effects. Normally, such a plan creates separation in time and/or space between the emitter and the undesired target.

The NASA Safety Center encourages all field Centers to check similar cranes to assure their signals/radio frequencies are not the same. In addition, there are many devices that are RF-controlled and need to be considered as part of any survey to inventory all RF emitters.

* **Space Station airlock construction at the Marshall Center:** A crane lifts the airlock for the International Space Station during construction in the Space Station Manufacturing Building at NASA's Marshall Space Flight Center in Huntsville, Ala.

National Aeronautics and Space Administration



NASA SAFETY CENTER CASE OF INTEREST
3/24/2008

Uncontrolled Energy

A wide range of power and found personnel from the first contractor working on switchgear. If it had not been for High voltage system control personnel inspecting certain areas, they would not have been aware of the first contractor working in the area. As a result, someone would have been injured because of not using lockout/tagout practices.

The OSHA standard for The Control of Hazardous Energy (Lockout/ Tagout), Title 29 Code of Federal Regulations (CFR) Part 1910.147 addresses the practices and procedures necessary to disable machinery or equipment, thereby preventing the release of hazardous energy while employees perform servicing and maintenance activities. The standard outlines measures for controlling hazardous energies—electrical, mechanical, hydraulic, pneumatic, chemical, thermal, and other energy sources. In addition, 29 CFR 1910.133 sets forth requirements to protect employees working on electric circuits and equipment. This section requires workers to use safe work practices, including lockout and tagging procedures. These provisions apply when employees are exposed to electrical hazards while working on, near, or with conductors or systems that use electric energy. Lockout/tagout violations consistently rank in the top five of OSHA's most frequently cited standards.

The NASA Safety Center encourages all field Centers to educate their workforce on the dangers involved in all aspects of equipment maintenance and the proper application of lockout/tagout techniques.

Using the knowledge sharing product

What YOU can do...

- ▶ Identify where to infuse the corrective and preventative actions into current processes to mitigate or eliminate those precursors and hazards identified in the Col
- ▶ Identify personnel that would be integrators, implementers and disseminators of this information or adjust expertise required to address current and potential hazards
- ▶ Expedite communication on these precursors and hazards to your team

Read it and recognize the hazard or risk

Make relevant personnel aware

Perform preventative action

Col Review promotes Mission success

What this will do for your team...

- ▶ Provides a basis for a broader discussion of precursors and hazards related to a particular topic
- ▶ Assists identification of “gaps” in current requirements, contracts/contract processes, training, operational processes
- ▶ Facilitates timely hazard identification and safety awareness and development of effective countermeasures

COI - Where to find....

The screenshot displays the NASA Safety Center (NSC) website. At the top, the NASA logo and 'National Aeronautics and Space Administration' are visible. Below this is the 'NSC NASA SAFETY CENTER' banner. The main content area includes a 'Welcome to the NSC' message from the NSC Director, Alan Phillips, and a 'NSC Vision' statement. A central organizational chart shows the NSC structure with branches for Technical Excellence, Audits & Assessments, Knowledge Management, and Mishap Investigation. The left sidebar contains sections for 'Safety Bulletin', 'Agency Safety Metrics', 'Agency Safety Trends', and 'SMA Services'. The right sidebar features 'Featured Case Studies' and 'Featured Training'. The bottom of the page includes a calendar for February 2007, a 'Partners' section with logos for APPEL, NEN, and SATERN, and a 'NSC Events' section with dates for February 17 and 24, 2007.

- ▶ The CoI is posted on the NSC website: (<http://nasa.nsc.gov>)
- ▶ The CoI provides links to relevant areas of the NSC website and or other agency websites
- ▶ Electronic distribution of PDF versions

Case of Interest PBMA workgroup

Additional information can be found by joining the PBMA Col working group.

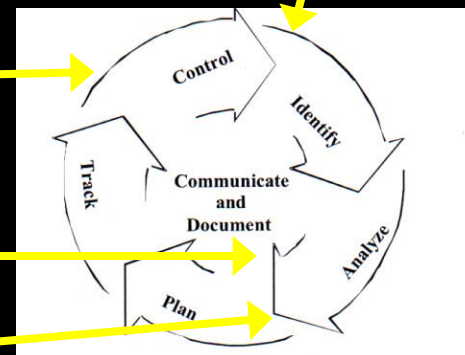
IRIS #	Date	Site	Classification	Description			
2008-042-00009	2/8/2008 11:50	JPL	Type D	JPL#1598 - Power outage of entire MSSCC complex.			
Detailed Description			Amplifying Information, Analyst Questions				
See attached "Accident Notification Form." Note: 2008-039-00007 was a duplicate entry and has been deleted.			A worker of the "UTE Complejo Especial" was working on a high voltage panel. When he tried to connect to ground a high voltage conductor, it flared. When standing back he slightly banged his head. Worker had hard hat, electrical face shield, electrical gloves and insulating rug. Several electrical components of the panel burned (transformers, coils, etc).				
Severity	Likely	Complex	Coupled	Control Failure	Latent Condition	Doc	CAP
Injury	Yes	No	No	1:1 Unidentified hazard	Energized circuit	No	No
Av/Op S&MA		Quality Eng		R&M	Software Safety	Systems Safety	
Yes		Maybe-insufficient cause data		Yes	No	Yes	

Latent Condition!

Failed Control!

Broad Effects!

Catastrophic Outcome!



Summary

- ▶ There are great case study resources out there to help create stronger project teams
 - ▶ Insight
 - ▶ Communication
 - ▶ Teambuilding
- ▶ The ball is now in your court to take advantage of these resources and plan to use them
- ▶ Contact: nasa-nsc@nasa.gov